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Amphibia, Anura, Hylidae, *Boana wavrini* (Parker, 1936): distribution extension in the Colombian Llanos

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Abstract
We report the presence of *Boana wavrini* in Arauca and Vichada departments (Llanos of Colombia). These localities extend the known range of this species by more than 283 km to the north from the previously known occurrences. In addition, we describe some aspects of the natural history of this species.

Key words
Colombia; savannas; llanos; Orinoco River; range extension; tadpoles; habitat.

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Introduction

The Neotropical genus *Boana* Gray, 1825 contains 92 described species distributed throughout the Neotropics from Nicaragua to Argentina (Frost 2017). In Colombia, there are 22 species of *Boana* mainly found in the lowlands (Acosta-Galvis 2017). Three of these species (*Boana boans* (Linnaeus, 1758), *B. geographica* (Spix, 1824), and *B. wavrini* (Parker, 1931)) stand out by having specialized nesting behavior; they almost always select sites on the edges of bodies of water where they build their nests. These species can be recognized by the presence of a reticulated palpebral membrane and small dermal projections on the heels, characters that place them in the *Boana semilineata* species group (Hoogmoed 1990, Martins and Moreira 1991, Faivovich et al. 2005).

One of these species, *B. wavrini*, broadly encompasses central Amazonia (80–400 m above sea level) in the state of Amazonas, southern Venezuela and in the states of Amazonas, Roraima, Pará, Rondônia, and Mato Grosso, Brazil (Hoogmoed 1990, Martins and Moreira 1991, Gorzula and Senaris 1998). Additionally its distribution in Colombia is geographically associated with the Guiana Shield along the Orinoco River, and it can only be found in the Guainía (Puerto Inírida Municipality), Vaupés (Caparú Biological Station, Taraira Municipality) and Vichada (El Tuparro National Natural Park at Cumaribo Municipality) departments (Ruiz-Carranza et al. 1996, Acosta-Galvis 2000, Lynch and Vargas-Ramirez 2000, Lynch and Suárez-Mayorga 2001, 2011). Here we report new records of *B. wavrini* in other Colombian departments, which extend the known distribution of this species 283 km to the north of previously known occurrences.

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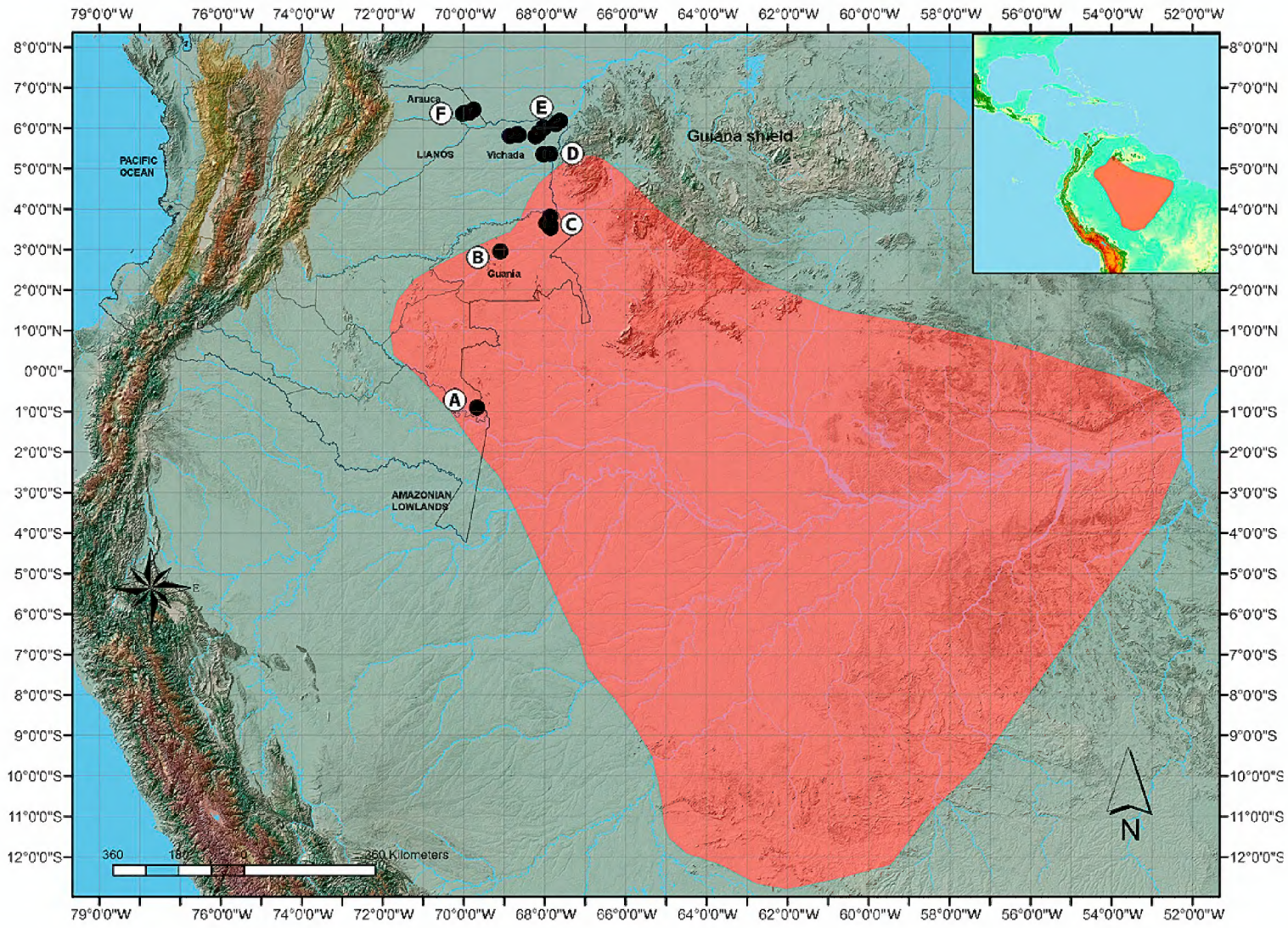

Figure 1. Currently known distribution of *Boana wavrini* (red Polygon, IUCN Red List) based on published scientific literature (Hoogmoed 1990, Martins and Moreira 1991, Lynch and Vargas-Ramirez 2000). **A–C**. Previous Colombian localities published (Acosta-Galvis 2000, Lynch and Vargas-Ramirez 2000, Lynch and Suárez-Mayorga 2001). **D.** Additional specimens deposited in the collection of amphibians of the Humboldt Institute (IAvH-Am), and not published in the scientific literature; from Cumaribo municipality (Tuparro, Natural National Park), Vichada Department (IAvH-Am-7515-7, IAvH-Am-7533, IAvH-Am-7547-9, IAvH-Am-7553-4, IAvH-Am-7598). **E.** New records at Bita River, Vichada Department. **F.** New records in Arauca Department.

Methods

We examined 57 specimens, of which 8 were previously deposited in the Amphibian Collection (Table 1, Fig. 1) of the Alexander von Humboldt Biological Resources Research Institute, Villa de Leyva Boyacá, Colombia (IAvH-Am); 49 were collected during 4 separate field expeditions to Vichada and Arauca departments, including both in the rainy and dry seasons (Table 1, Figs 2, 8). The specimens were collected using active manual capture methods that include aquatic and terrestrial transects associated with riparian landscapes. Specimens were euthanized in benzocaine and fixed in 10% formalin solution, then transferred to 70% ethanol. Identification was made using Hoogmoed (1990) and voucher specimens were deposited in IAvH-Am (Table 1). We also examined additional specimens of *B. wavrini* from other nearby localities (Fig. 1A–C).

Results

Boana wavrini is a large frog (SVL 75–113 mm) that can be distinguished from *B. boans*, according to Hoogmoed (1990), by the following features (those of *B. boans* in parentheses, Fig. 3): Throat in males with dark radiating stripes (Fig. 3A), rounded spots separated by dark network (uniform in *B. boans,* Fig. 3B). Iris color in life reddish brown (Fig. 3C) to grayish (golden in *B. boans*, Fig. 3D). Fingers extensively webbed, fourth finger with penultimate phalanx free (webbing reaches disc in *B. boans*). Subarticular tubercles fingers pronounced (not very distinct in *B. boans*). Discs fingers distinctly smaller than tympanum (completely covering tympanum in *B. boans*). Webbing of the fourth toe does not reach disc (reaches disc in *B. boans*). Median ridge on side of tibia absent (on posterior region, connected with heel appendage in *B. boans*). Heel appendage transverse ridge with lateral triangular flap (Fig. 3E) (transverse ridge with small triangular tubercle in *B. boans*, Fig. 3F) C*anthus rostralis* straight (concave in *B. boans*), and snout anteriorly truncate (concave in *B. boans*).

As part of the results obtained from 4 field expeditions, we also recorded natural history data on Colombian populations of *B. wavrini* (Table 1, Fig. 1). In the dry season (January 2016), ARA obtained 14 specimens from the ground on sandbanks or from shrubs in gallery forests (Site B, Table 1, Figs 2, 5). These series consist of 6 adult females (SVL 85.7–101.0 mm), together with 8 adult males (SVL 85.6–98.3 mm); 1 adult male (IAvH-Am-11858) was recorded vocalizing on dry shrubs at 30 cm above the ground at an environmental temperature of 32 °C and 68% relative humidity. Additional specimens (site C, Table 1, Fig. 2) were obtained by ARA from the edge of the Bita River. The series includes 5 females (SVL 81.7–98.8 mm) and 7 males (SVL 91.0–101.2 mm) that were located vocalizing at the base of the trees and shrubs along shore. Two additional specimens that include 1 juvenile IAvH-Am-11873 (SVL 71.0 mm) and 1 adult female IAvH-Am-11874 (SVL 94.3 mm) were located in transitional areas between morichales (the local

Table 1. List of localities with records of *Boana wavrini* in the Colombian Llanos. The presence of each voucher in individual localities, date, and season of the year (indicated with an "X") are included.

Locality	Latitude (W)	Longitude (W)	Elev. (m)	Geographical location	Date	Season		Voucher specimens
						Dry	Wet	
Site A (Fig. 2)	06°05′40″N	67°43′34″	35	Lower Bita River, La Pedregoza Natural Reserve,Vereda Caño Negro, Puerto Carreño Municipality ,Vichada Department (Fig. 4)	7 Aug. 2012		X	Adult males: IAvH-Am-11584-6
Site B (Fig. 2)	05°51′02″N	68°40′10″	71	Middle Bita River, La Danta Creek, Maracana farm, La Primavera Municipality, Vichada Department (Fig. 5)	13–15 Jan. 2016	X		Adult males IAvH-Am-11855-8, IAvH-Am-11860, IAvH-Am-11862 and IAvH-Am-11865; adult females IAvH-Am-11853-4, IAvH-Am-11859, IAvH-Am-11863-4 and IAvH-Am-11866
Site C (Fig. 2)	05°51′38″–05°52′32″	068°09′18″–068°09′55″	48–62	Middle Bita River, Mi Familia farm, Puerto Carreño Municipality, Vichada Department	18–19 Jan. 2016	X		Adult males IAvH-Am-11867-9, IAvH-Am-11872, IAvH-Am-11876 -7, IAvH-Am-11881; adult females IAvH-Am-11870-1, 11874, IAvH-Am-11878-9, IAvH-Am-11882; juvenile IAvH-Am-11873
Site D (Fig. 2)	05°49′45″N	068°11′30″	54	Middle Bita River, Site Anakay (base camp), Puerto Carreño Municipality, Vichada Department	20 Jan. 2016	X		Adult males IAvH-Am-11883-5; juveniles IAvH-Am-11875, IAvH-Am-11880, IAvH-Am-11884
Site E (Fig. 2, Table 2)	05°48′04″N	068°13′12″	65	Middle Bita River, Puerto Carreño Municipality, Vichada Department	19 Jan. 2016	X		Tadpole stage 28 sensu Gosner (1960) IAvH-Am-11931
Site F (Fig. 2, Table 2)	05°51′09″N	068°09′40″	63	Middle Bita River, Puerto Carreño Municipality, Vichada Department	21 Jan. 2016	X		Tadpole stage 39 sensu Gosner (1960) IAvH-Am-11930; tadpole stage 28 sensu Gosner (1960) IAvH-Am-11933
Site G (Fig. 2)	05°52′44″	068°09′15″	63	Middle Bita River, El Mosco Creek, Puerto Carreño Municipality, Vichada Department	23 Jan. 2016	X		Tadpole stage 26–28 sensu Gosner (1960) IAvH-Am-11934
Site H (Fig. 2, Table 2)	05°51′09″	068°09′40″	63	Middle Bita River, El Tijero Creek, Puerto Carreño Municipality, Vichada Department	23 Jan. 2016	X		Tadpoles stages 28–39 sensu Gosner (1960) IAvH-Am-11932
Site I (Fig. 2)	05°48′22″	068°51′28″	61	Middle Bita River, La Florida Farm, La Primavera Municipality, Vichada Department	25 May 2016		X	Adult female IAvH-Am-13878
Site J (Fig. 8)	06°27′20″	069°45′12″	96	Araguato Creek, Cravo Norte Municipality, Arauca Department	20 Apr. 2016		X	Adult male IAvH-Am-14360
Site K (Fig. 8)	06°24′49″	069°51′32″	95	La Palmira Farm, Cravo Norte Municipality, Arauca Department	20 Apr. 2016		X	Heard by LER
Site L (Fig. 8)	06°21′19″	70°0′37.8″	96	La Aurora Farm, Cravo Norte Municipality, Arauca Department	May 2016		X	Heard by LER
Site M (Fig. 8)	06°22′45″	69°05′44″	100	La Aurora Farm, Cravo Norte Municipality, Arauca Department	1 May 2016		X	Adult male IAvH-Am-14361

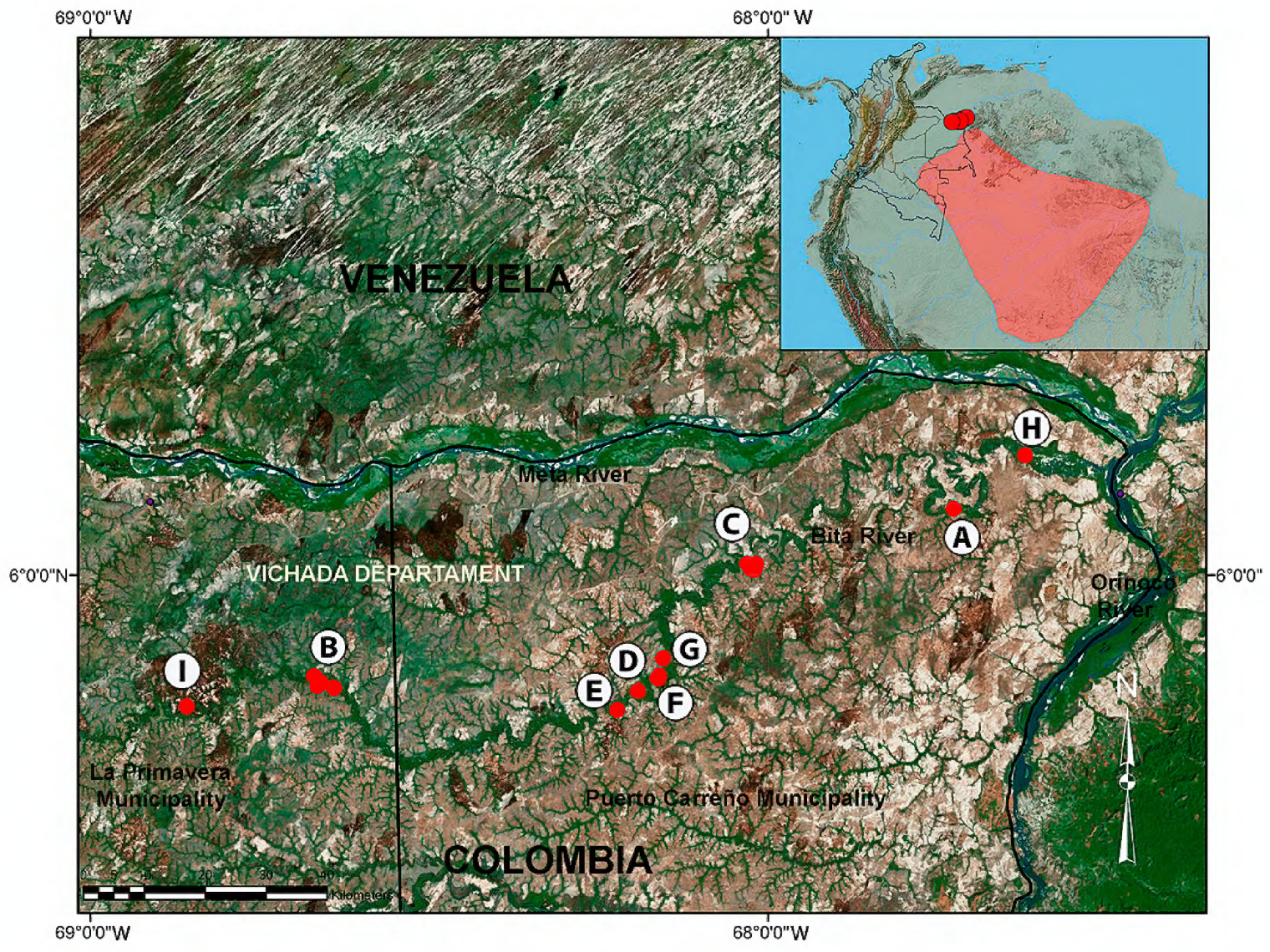

Figure 2. New records of *Boana wavrini* at Bita River, Vichada Department, in Llanos of Colombia (Table 1). Site A. Puerto Carreño municipality at Vereda Caño Negro, La Pedregoza Natural Reserve. Site B. La Danta stream afferent to the Bita River, at Maracana farm. Site C. Mi Familia farm, Puerto Carreño municipality. Site D. Middle Bita River at Anakay. Site E. Middle Bita River drainage. Site F. The old channel at Bita River Site G. El Mosco Creek. Site H. El Tijero Creek Site I. La Primavera Municipality, La Florida Farm.

Figure 3. Morphological characters differences between *Boana wavrini* and *B. boans*. **A.** Adult male of *B. wavrini* IAvH 11868 (SVL 92.3 mm) from Bita River, Vichada, Colombia; arrows indicate the pattern of reticulations in throat. **B.** Adult male of *B. boans* IAvH 14388 (SVL 88.4 mm) from Antioquia, Colombia; arrow indicate the uniform pattern in throat. **C.** Adult female of *B. wavrini* IAvH 11864 (SVL 101.4 mm) from Bita River, Vichada, Colombia; arrow indicate iris color in life reddish brown. **D.** Adult male of *B. boans* IAvH 14386 (SVL 83.6 mm) from Antioquia, Colombia; arrow indicate iris color in life golden. **E.** Dorsal view of heels of *Boana wavrini* IAvH 11869 (SVL 98.9 mm) from Bita River, Vichada; note the heel appendage with lateral triangular flap. **F.** Dorsal view of heels of adult male of *B. boans* IAvH 14388 (SVL 88.4 mm) from Antioquia, Colombia; note the heel appendage with small triangular tubercle. Scale bars = 5 mm. Photographs: Andrés Acosta.

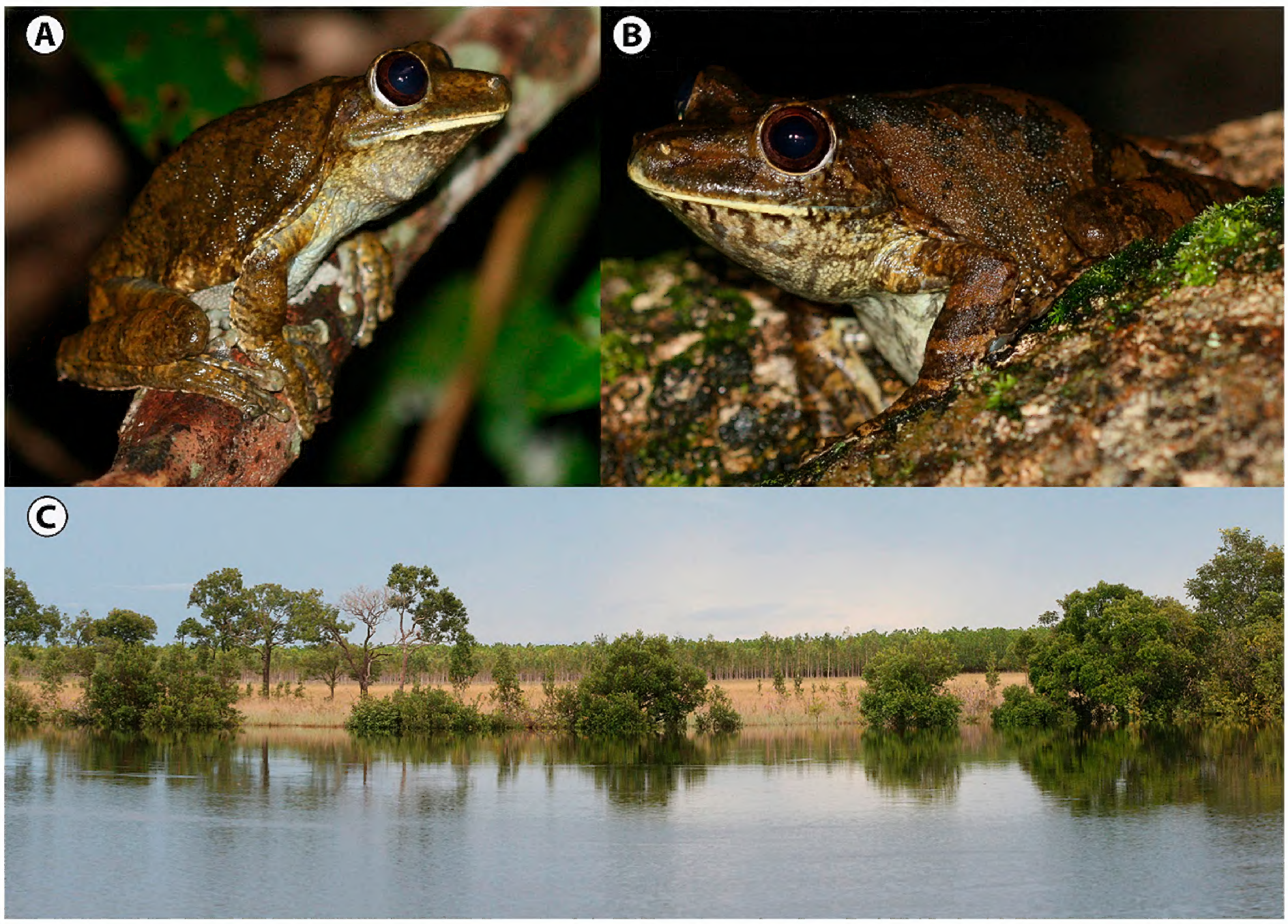

Figure 4. Lateral view of *Boana wavrini*, adult males. **A.** IAvH-Am-11586 (SVL 97.7 mm). **B.** IAvH-Am-11584 (SVL 112.4 mm). **C.** Habitat in rainy season, from Bita River in Vichada department, Puerto Carreño municipality at Vereda Caño Negro, La Pedregoza Natural Reserve, (site A). Photographs: Andrés Acosta.

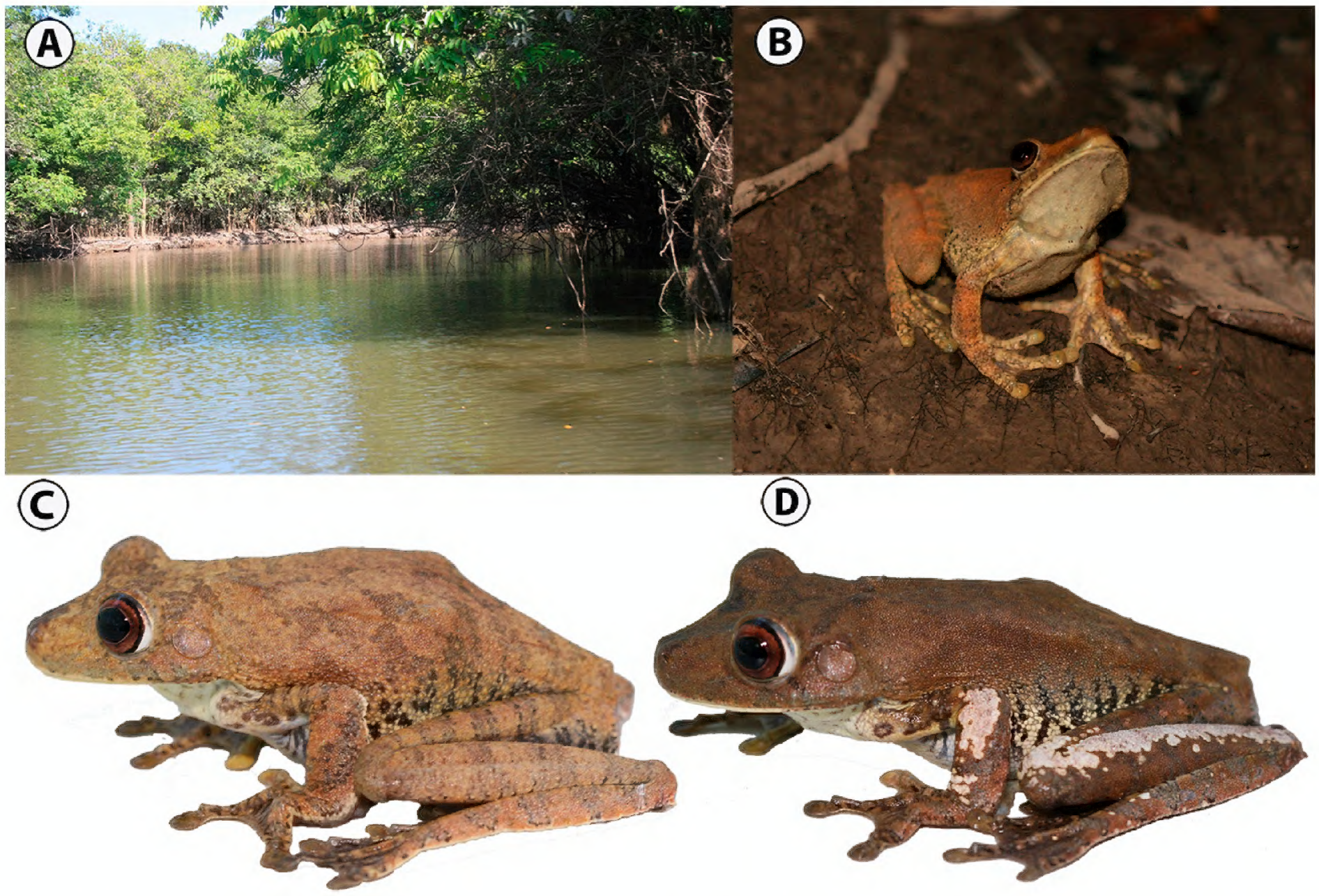

Figure 5. A. Habitat in dry season at La Danta stream from Bita River in Vichada Department, La Primavera municipality (site B). **B.** Specimen released on the floor on sandbanks La Danta stream. **C.** Chromatic variation in lateral view of *Boana wavrini*, at La Danta stream, adult females**.** IAvH-Am-11854 (SVL 91.7 mm). **D.** IAvH-Am-11853 (SVL 89.1 mm), Photographs: Andrés Acosta.

name in Colombia and Venezuela for groves of *Mauritia flexuosa* palm swamps) and open savannas. During nocturnal transects along the sandbank margins of the Bita River and 1 of its tributaries (site D, Table 1, Fig. 2), ARA collected a series of 3 adult males (SVL 91.5–102.7 mm) that included a specimen (IAvH-Am-11883, SVL 102.7 mm) that lacks the distal extremity of a foot, and 3 juveniles (SVL 21.3–70.5 mm, Fig. 6).

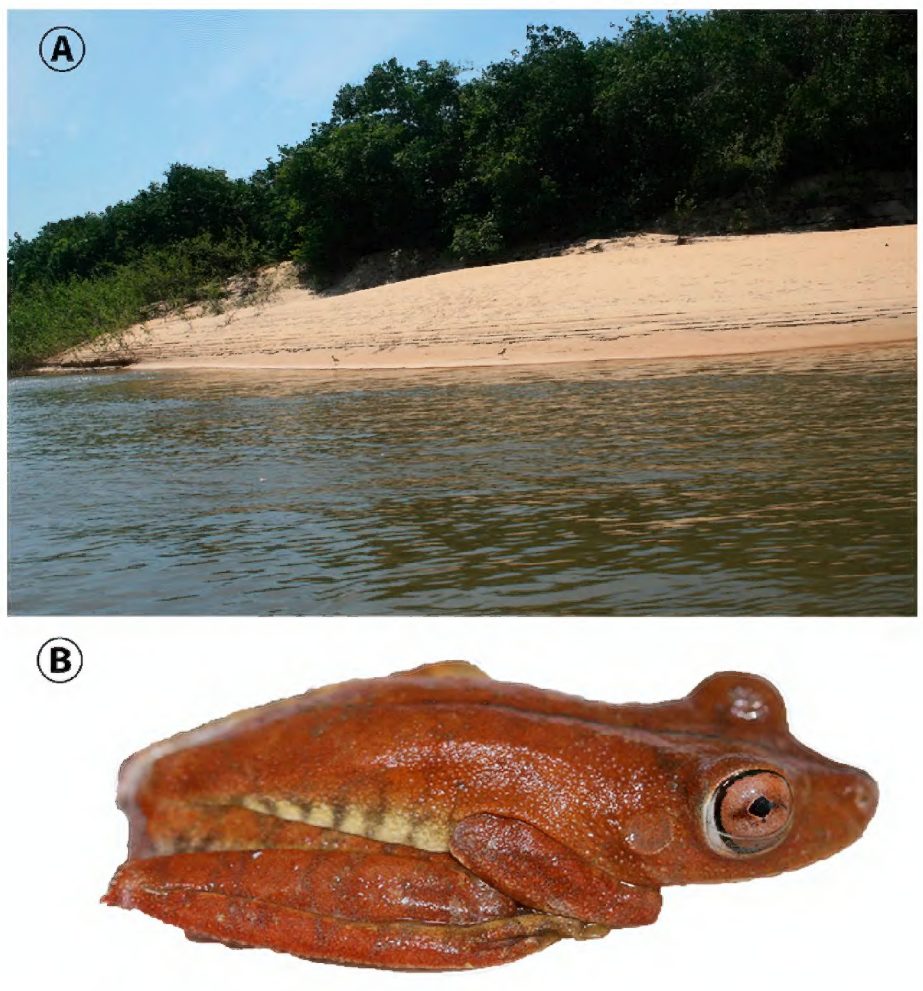

Figure 6. Habitat of juveniles and tadpoles from *Boana wavrini* in dry season, Bita River in Vichada department, La Primavera municipality. **A.** Juvenile specimen IAvH-Am-11880 (SVL 36.6 mm) **B.** Sandbanks at the edge of the Bita River where the specimens were collected. Photographs: Andrés Acosta.

In addition to the above observations, during the dry season (January 2016), IAvH ichthyologists collected a series of tadpoles at different points along the Bita River. A single tadpole (IAvH-Am-11931) was obtained from the shallower sandbank margin of the river (site E, Tables 1, 2, Fig. 2). Two single tadpoles (IAvH-Am-11930, IAvH-Am-11933) were collected in different stages at sampling points very close to the old channel (site F, Table 1, Table 2, Fig. 2) of the Bita River. An aquatic prospection in the shallow shore of Mosco Creek (site G, Table 1, Fig. 2), allowed the collection of several tadpoles IAvH-Am-11934 ($N = 11$, stages 26–28

Table 2. Physical and chemical characteristics of water at different points along the Bita River, where *Boanas wavrini* tadpoles were collected. For details on sampling localities, see Table 1.

Localities	Conductivity ($\mu S \cdot cm^{-1}$)	Temperature (°C)	Dissolved oxygen (mg/L)	pH
site E	6.1	30.0	10.9	—
Site F a	83.4	30.6	9.3	7.29
Site F b	130.0	30.7	10.8	7.29
Site H	4.9	31.4	7.5	9.7

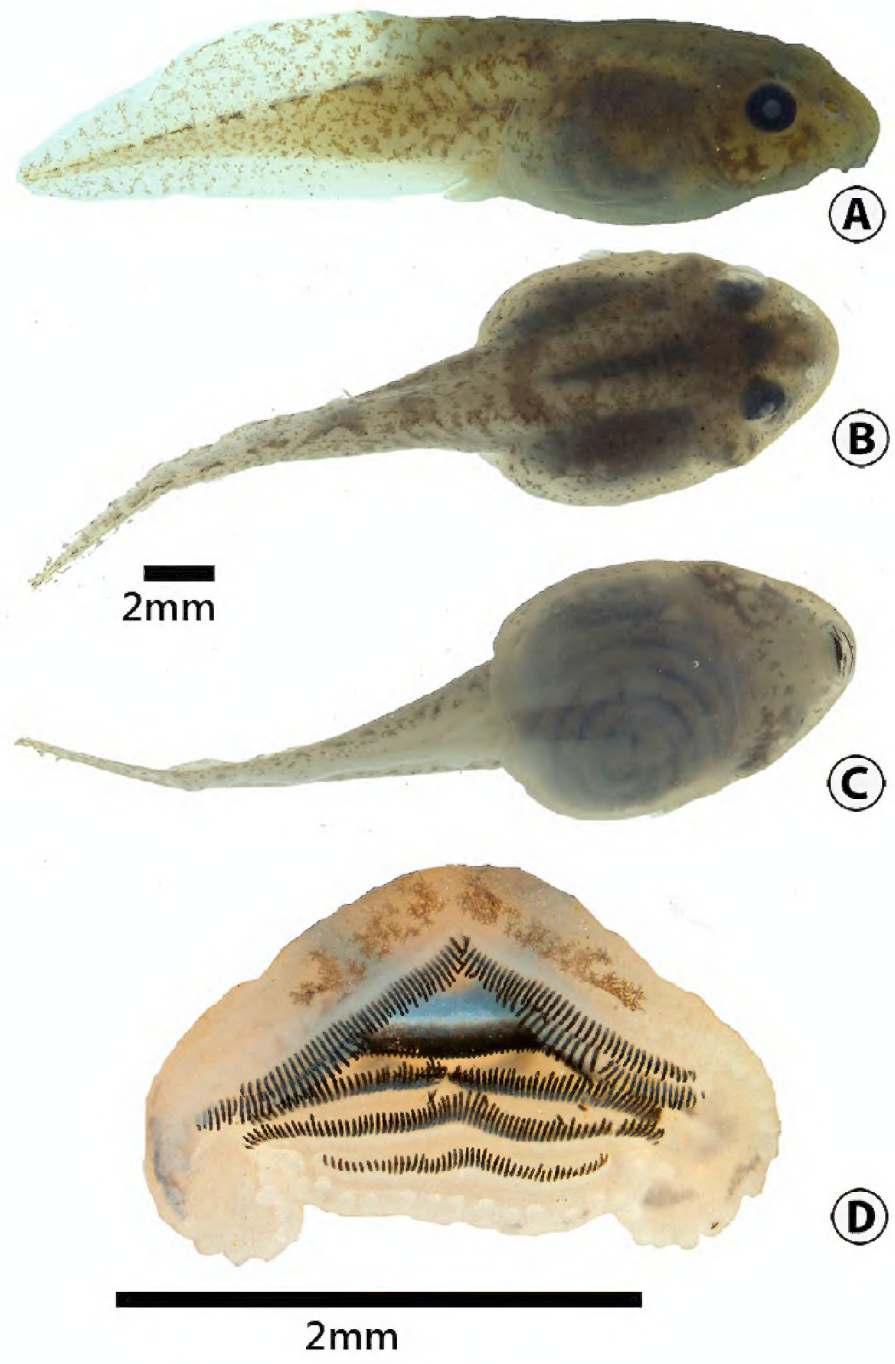

Figure 7. Tadpole of *Boana wavrini* specimen IAvH 11932 stage 32 *sensu* Gosner (1960) from El Tijero Creek in Bita River drainage (Vichada). **A.** Lateral view. **B.** Dorsal view. **C.** Ventral view. **D.** Detail of oral disk. Scale bar = 2 mm. Photograph: Andrés Acosta.

sensu Gosner, 1960). Finally, tadpoles IAvH-Am-11932 ($N = 3$, Fig. 7) were also collected on a sandbank associated with the mouth of the El Tijero Creek (site H, Table 1, Table 2, Fig. 2). Together, the previously mentioned localities (sites B–G, Table 1, Fig. 2) are geographically close and extend the distribution of *B. wavrini* approximately 122 km northwest from the distribution in Amazonas state, Venezuela.

During the rainy season (August 2012) ARA heard, recorded and collected (Site A, Figs 2, 4) 3 adult males (SVL 96.4–112.4 mm) calling, from tree tops over flooded shore areas in gallery forests of the Bita River, at about 134 km northwest from the closest previously reported occurrence in Amazonas State, Venezuela. Complementary field samples during the rainy season (May 2016) obtained just 1 adult female (SVL 104.7 mm, Table 1) from the middle drainage of the Bita River (Site I, Table 1, Fig. 2), in landscapes associated with *Mauritia flexuosa* palm swamps, extending the geographic range about 149 km northwest from a previous occurrence in the state of Amazonas, Venezuela. Simultaneous to the previous field expedition during the rainy season (April and May 2016), LER obtained, during inventories in the eastern region of Arauca Department (Sites J–M, Table 1, Fig. 8), the northernmost records of *B. wavrini* that extend its geographic range approximately 283 km northwest from an occurrence in the state of Amazonas, Venezuela. LER heard vocalizations of a series of 13 specimens and collected a single male (SVL 115.5 mm, Table 1) in gallery forest from Araguato Creek (site J, Table 1, Fig. 8). Four additional specimens were recorded (site K , Table 1, Fig. 8); another 4 specimens were heard (site L, Table

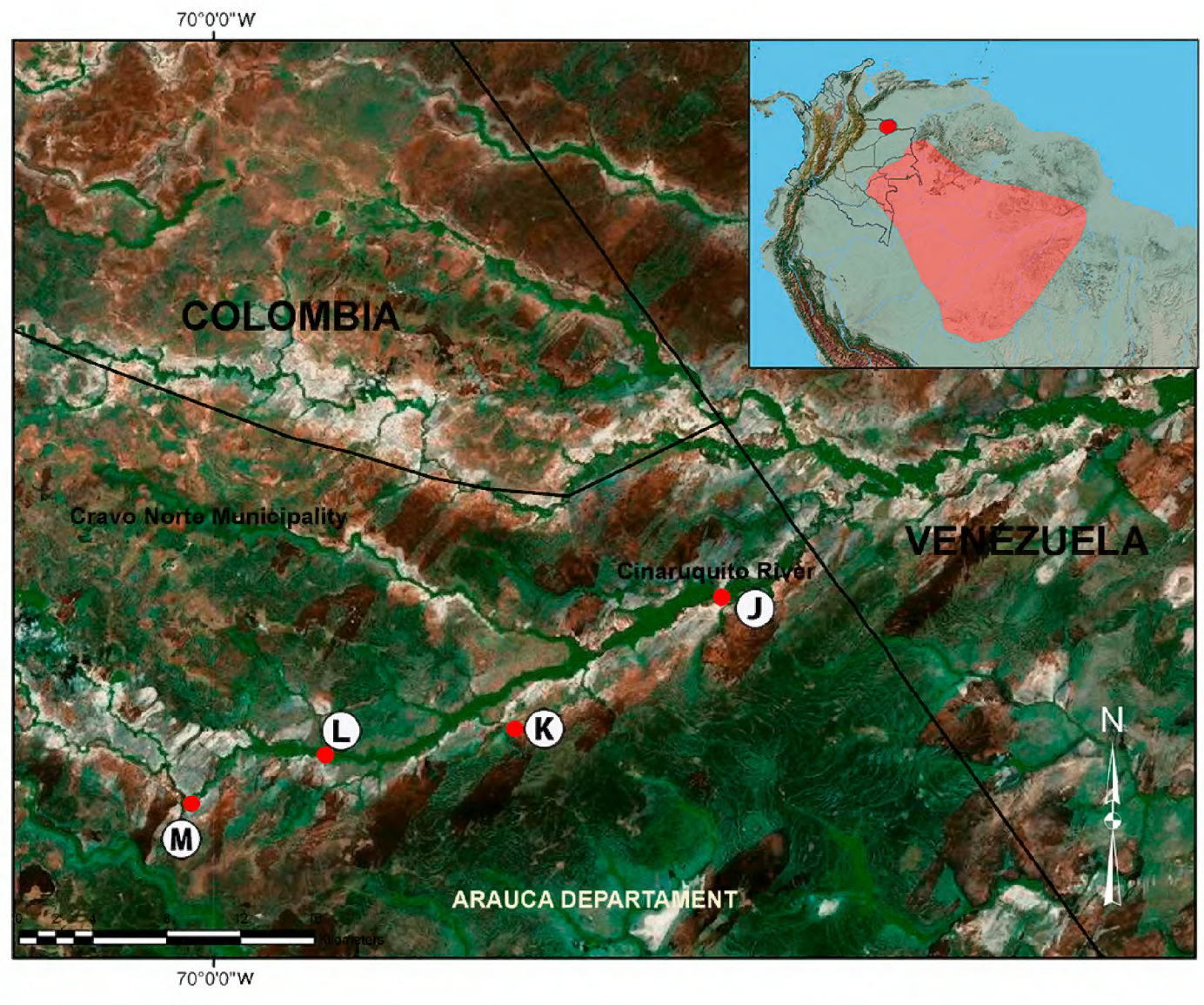

Figure 8. New records of *Boana wavrini* at Cravo Norte Municipality, Arauca Department, in Llanos of Colombia (Table 1). Site J. Caño Araguato. Site K. La Palmira Farm. Site L. La Aurora Farm. Site M. La Reserva Farm.

1, Fig. 8) and 2 specimens were recorded (1 of them an adult male collected, SVL 86.3 mm) in a gallery forest (site M, Table 1, Fig. 8).

Discussion

These new records of *Boana wavrini* from the departments of Arauca and Vichada represent the first records from the Llanos of Colombia and extend the distribution of this species 283 km north of the nearest previously known occurrences (Fig. 1). As previously observed in populations from Venezuela (Hoogmoed 1990), Brazil (Martins and Moreira 1991), and Colombia (Lynch and Vargas 2000), *B. wavrini* is a nocturnal riverine species associated with gallery forests and various riparian environments such as morichales (i.e. *Mauritia flexuosa* palm swamps), creeks, and lagoons.

Four expeditions at different times of the year suggest that *B. wavrini* is asynchronous when compared to other anurans of savannah ecosystems, because this species seems to have higher reproductive activity during the dry season. This is evidenced by an apparent higher abundance and presence of individuals in different stages of development (Table 1), the presence of tadpoles in stages 28–38 (Table 2), and various mating calls recorded at the end of the rainy season (specimen vouchers: IAvH-Am-11584-6, IAvH-Am-11858) in Vichada (Bita River). Our observations suggests that reproductive events of *B. wavrini* begin in the dry season at the end of the year, likely extending from December to April, when the water level drops, exposing sandy beaches, which are the reproductive microhabitat of this species. In contrast, most savanna (Llanos) anuran species breed at the beginning of the rainy season (April and May) in more terrestrial environments. Call and reproduction data from Brazilian populations of *B. wavrini* (Martins and Moreira 1991) corroborate this pattern.

Hoogmoed (1990) evaluated the populations of Venezuela, Brazil, and Suriname and stated that one of the distinctive diagnostic features of *B. wavrini,* compared to other species of the *B. semilineata* group, is their large body size. The SVL of males is 89–113 mm and of adult females 75–81 mm. Our evaluation of 58 specimens confirms the same pattern observed by Hoogmoed (adult males SVL = 85.6–115 mm; adult females SVL = 80.2–109 mm). In contrast, in the Amazonian populations of Colombia (Lynch and Vargas 2000) larger specimens were recorded (adult males SVL = 69.0–134.3 mm; adult females SVL = 95.6–132.1 mm).

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Authors' Contributions

ARA and LER collected the specimens, reviewed literature and wrote the text; ARA reviewed the museum specimens, made the morphological measurements, and analyzed the data.

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